

CLAIMS

1 1. A method of fabricating a microelectromechanical system, said method comprising:
2 providing a substrate comprising a handle layer of silicon, a device layer of silicon
3 and a sacrificial layer of silicon disposed between said handle layer and said device layer;
4 forming a micromechanical structure in said device layer; and
5 removing at least a portion of said sacrificial layer of silicon underlying said
6 micromechanical structure to release said micromechanical structure for movement

1 2. A method of fabricating a microelectromechanical system, as per claim 1, wherein said
2 silicon of said sacrificial layer is single crystal silicon.

1 3. A method of fabricating a microelectromechanical system, as per claim 1, wherein said
2 forming step further comprises:
3 forming an isolation trench that extends through at least said device layer.

1 4. A method of fabricating a microelectromechanical system, as per claim 1, wherein said
2 handle layer is separated from said sacrificial layer by a first dielectric layer, said sacrificial layer
3 is separated from said device layer by a second dielectric layer, and said forming step further
4 comprises:
5 forming an isolation trench that extends through at least said sacrificial layer, said
6 isolation trench defining a release area in said sacrificial layer; and
7 etching said silicon of said device layer to form said micromechanical structure

1 5. A method of fabricating a microelectromechanical system, as per claim 4, wherein said
2 silicon of said device layer is polysilicon.

1 6. A method of fabricating a microelectromechanical system, as per claim 4, wherein said
2 silicon of said device layer is single crystal silicon.

1 7. A method of fabricating a microelectromechanical system, as per claim 4, wherein said
2 isolation trench additionally extends through said device layer.

1 8. A method of fabricating a microelectromechanical system, as per claim 4, said removing
2 step further comprising:

3 placing a photoresist layer on top of said device layer over at least said
4 micromechanical structure;

5 forming release etch holes through said photoresist layer and said second
6 dielectric layer; and

7 etching said sacrificial layer of silicon underlying said micromechanical structure.

1 9. A method of fabricating a microelectromechanical system, as per claim 8, wherein said
2 first dielectric layer is used as an etch stop for said etching of said sacrificial layer.

1 10. A method of fabricating a microelectromechanical system, as per claim 8, wherein said
2 second dielectric layer is used as an etch stop for said etching of said sacrificial layer.

1 11. A method of fabricating a microelectromechanical system, as per claim 8, wherein said
2 isolation trench is used as an etch stop for said etching of said sacrificial layer.

1 12. A method of fabricating a microelectromechanical system, as per claim 4, wherein said
2 handle layer has actuation electrodes formed thereon.

1 13. A method of fabricating a microelectromechanical system, as per claim 12, said forming
2 step further comprising:

3 forming via posts extending through at least said sacrificial layer to contact said
4 actuation electrodes.

1 14. A method of fabricating a microelectromechanical system, as per claim 13, wherein said
2 via posts additionally extend through said device layer.

1 15. A method of fabricating a microelectromechanical system, as per claim 4, wherein
2 actuation electrodes are formed on the bottom of said sacrificial layer.

1 16. A method of fabricating a microelectromechanical system, as per claim 1, said method
2 further comprising:

3 bonding a silicon-on-insulator wafer to a handle wafer of silicon to create said
4 substrate.

1 17. A method of fabricating a microelectromechanical system, as per claim 1, said method
2 further comprising:

3 bonding a first silicon-on-insulator wafer to a handle wafer of silicon and
4 removing a handle layer of said first silicon on insulator wafer to create said sacrificial layer; and

5 bonding a second silicon on insulator wafer to said sacrificial layer and removing
6 a handle layer of said second silicon on insulator wafer to create said device layer.

1 18. A method of fabricating a microelectromechanical system, as per claim 1, said method
2 further comprising:

3 bonding a first wafer of silicon to a second wafer of silicon;

4 bonding a third wafer of silicon to said first wafer of silicon; and

5 whereby said substrate is created.

1 19. A method of fabricating a microelectromechanical system, as per claim 1, wherein said
2 micromechanical structure is any one of: a micro-optical device, an inertial sensor, or an actuator.

1 20. A method of fabricating a microelectromechanical system, as per claim 19, wherein said
2 micro-optical device is a micromirror.

1 21. A method of releasing a micromechanical structure for movement, said micromechanical
2 structure etched in a silicon device layer, said method comprising:

3 etching a silicon sacrificial layer disposed between said micromechanical
4 structure and a silicon handle layer.

1 22. A method of releasing a micromechanical structure for movement, as per claim 21,
2 wherein said micromechanical structure is a micromirror.

1 23. A microfabricated device comprising:

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2 a substrate having a device layer;
3 a least one micro-optical device etched on said device layer and released for
4 movement by removal of an underlying sacrificial layer of silicon; and
5 active electronics formed on said device layer.

1 24. A microfabricated device as per claim 23, wherein said micro-optical device is a
2 micromirror.

1 25. A microfabricated device as per claim 23, wherein said active electronics are formed via
2 CMOS fabrication techniques.

1 26. A microfabricated device as per claim 23, wherein said silicon of said device layer is
2 single crystal silicon.

1 27. A microelectromechanical device comprising:
2 a handle layer of silicon having actuation electrodes formed thereon;
3 a device layer of silicon having a micromechanical structure formed thereon; and
4 a sacrificial layer of silicon disposed between said handle layer and said device
5 layer of silicon, said sacrificial layer of silicon having a portion underlying said micromechanical
6 structure removed to form an actuation cavity below said micromechanical structure.

1 28. A microelectromechanical device as per claim 27, further comprising:
2 at least one isolation trench extending through said device layer and said
3 sacrificial layer and enclosing said cavity and micromechanical structure.

1 29. A microelectromechanical device as per claim 28, wherein said isolation trench is lined
2 with a dielectric and filled with a conductive material.

1 30. A microelectromechanical device as per claim 29, wherein said dielectric is an oxide and
2 said conductive material is doped polysilicon.

1 31. A microelectromechanical device as per claim 27, further comprising:
2 at least one via post extending through said device and said sacrificial layer for
3 electrical connection to said actuation electrodes.

1 32. A microelectromechanical device as per claim 27, wherein said silicon of said device
2 layer is polysilicon.

1 33. A microelectromechanical device as per claim 27, wherein said silicon of said device
2 layer is single crystal silicon.

1 34. A microelectromechanical device as per claim 33, said device further comprising:
2 integrated electronics formed on said device layer.

1 35. A microelectromechanical device as per claim 34, wherein said integrated electronics
2 electrically connected to said actuation electrodes by at least one via post extending through said
3 device layer and said sacrificial layer.

1 36. A microelectromechanical device as per claim 27, wherein said micromechanical
2 structure is a micromirror.

37. A micromirror device comprising:

- a substrate having a device layer, a handle layer and a sacrificial layer made of silicon disposed between said device layer and said handle layer;
- an isolation trench extending through said device layer and said sacrificial layer, said isolation trench defining a mirror region and electrically isolating said mirror region;
- a mirror formed from said device layer in said mirror region above actuation electrodes formed on said handle layer; and
- a cavity formed below said mirror by removing a portion of said sacrificial layer of silicon.

38. A micromirror device as per claim 37, wherein said device layer is single crystal silicon

39. A micromirror device as per claim 38, said micromirror device further comprising:
active electronics formed on said substrate in said device layer.

40. A micromirror device as per claim 39, wherein said active electronics are connected to said actuation electrodes through a via post extending through said device layer and said sacrificial layer.

41. A micromirror device as per claim 37, wherein said mirror comprises:

- a central mirror plate;
- a concentric suspension ring connected to said central mirror plate;
- a frame formed from said device layer in said mirror region; and

5 wherein said mirror is connected to said frame via flexures, said flexures comprise
6 a first set of flexures connected between said central mirror plate and said concentric suspension
7 ring and a second set of orthogonally oriented flexures connected between said concentric
8 suspension ring and said frame.

1 42. A micromirror device as per claim 41, wherein said central mirror plate has a coating of
2 reflective material thereon.